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A PILOT STUDY OF AIR POLLUTION IN LYNCHBURG, VIRGINIA, FEBRUARY 9-15, 1961

Lynchburg, Virginia

15 February 1961

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City of Lynchburg

and

Public Health Service

A PILOT STUDY OF

AIR POLLUTION

IN

LYNCHBURG, VIRGINIA

February 9-15, 1961

Details of illustrations in
this document may be better
studied on microfiche

A Cooperative Study

by

City of Lynchburg

and

Public Health Service
U. S. Department of Health, Education and Welfare

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Introduction

Lynchburg is located in the deep, narrow James River Valley at the foothills of the Blue Ridge Mountains in Central Virginia. In 1950 the population of Lynchburg was 47,727; the 1960 census figures indicate a population of 54,790. This indicates an increase of about 15 per cent during the past ten years. It is assumed that the population will continue to increase in the future and, consequently, air pollutants released to the atmosphere from motor vehicles, from the combustion of fuels for heating, commercial and industrial processes, as well as from other general population activities will continue to increase.

Since 1945, there have been complaints about smoke, odors, and smog in Lynchburg. This was climaxed by an incident of paint blackening on a group of houses in 1958. This resulted in a request being made to the Virginia Department of Health and the Public Health Service for assistance in appraising the Lynchburg air pollution problem. A report covering this appraisal will be released in the near future.

Following the appraisal of the problem it seemed advisable to carry out a pilot study to obtain initial data on the general air pollution levels in Lynchburg and at the same time provide

experience and training for city employees in air pollution sampling. Similar pilot studies have been previously carried out, on a cooperative basis, by the Public Health Service and respective state and local agencies in Washington, D. C.; Phoenix, Arizona; Tucson, Arizona; Fresno, California; and Reno, Nevada.

Summary of Results

Because of the many variations in topography, prevailing wind speed and direction in the Lynchburg area, the results obtained by this short-term study should only be considered indicative of the magnitude of air pollutants. Other areas of the City, due to their location, the time of the year, prevailing weather conditions, may certainly have higher or lower levels of air pollutants than were found during this study.

Results of the one-week study may be summarized as follows:

1. The levels found give a clear indication that Lynchburg has an air pollution problem.

2. The levels found for soiling capacity and particulate matter indicate the presence of a general smoke problem.

3. The visibility standard for ambient air of the California State Health Department (less than three miles at less than 70 per cent relative humidity) was exceeded on six days, another indication of high particulate levels and smoke.

4. A combination of meteorological conditions, including low wind speed, temperature inversion, and a haze layer at the top rim of the James River Valley were noted on

February 15. The highest levels of general air pollution for the entire sampling period occurred during this period and appear to be attributable to the combined meteorological conditions.

5. The high level of sulfur dioxide is comparable to levels found in many large population centers or highly industrialized areas.

6. The levels for some of the gaseous pollutants are about average for urban areas; however, under conditions of low wind speed and temperature inversion, they may accumulate until much higher levels are reached.

Recommendations

Based on information contained in the preliminary appraisal report on air pollution in Lynchburg and the data obtained during this short-term study, the following recommendations are made:

1. A full-time air pollution control program should be established in the City of Lynchburg, with adequate personnel, funds, and equipment provided to cope with the problem.

2. An ordinance should be enacted or other authority provided for the development and promulgation of adequate rules and regulations for air pollution control.

3. The full-time air pollution control program should include:

   a. Routine air quality monitoring for particulate and gaseous pollutants to more fully delineate the air pollution problem in other areas of the City and during other types of meteorological conditions and other times of the year.

   b. Inventory and assessment of air pollution sources to more fully define the types and quantities of air pollution emissions.

c. A public education program for the dissemination of air pollution information and the development of community action and support for effective air pollution control.

d. Implementation of effective air pollution control, directed toward smoke abatement in the beginning and expanded to include abatement of other pollution emissions as the basic information and technical competency of the control activity is developed.

4. Support be given to the enactment of state legislation for air pollution control districts so that the problem can be approached on a metropolitan area basis because air pollution knows no political boundaries.

5. Future highway and zoning requirements should seriously consider the air pollution potential of any increased activities within the confines of the James River Valley or its tributaries.

Conduct of Study

The study was planned to provide intensive air pollution sampling for seven days, February 9-15, including one weekend and one all-night sampling period. The gaseous and particulate pollutants under test were selected to be indicative of the general levels of air pollution. Visibility measurements to ground level objects were taken every hour. The sewage treatment plant was selected as the air sampling site because it provided a suitable location with available laboratory facilities.

The Tests

Sampling was done for oxidant, nitric oxide, nitrogen dioxide, carbon monoxide, sulfur dioxide, hydrogen sulfide, and particulate matter. Gaseous pollutants were sampled by pumping outdoor air at measured rates through liquid chemical solutions or chemically impregnated granules or tape. Oxidant samples were collected for ten-minute periods every hour and nitric oxide, nitrogen dioxide, carbon monoxide, sulfur dioxide samples were collected for thirty-minute periods every two hours. Hydrogen sulfide was measured with a sampler that draws a metered amount of outside air (about 0.2 cfm) through a lead acetate impregnated filter paper. The sampler was allowed to operate continuously for twenty-four hours per

day, using three-hour sampling periods. Soiling capacity was measured with an AISI sampler that draws a metered amount (about 0.2 cfm) of outside air through a special filter paper. The sampler was allowed to operate continuously for twenty-four hours a day, using a three-hour sampling period. The hydrogen sulfide and AISI filter papers were evaluated with a "spot evaluation" photoelectric device that measures light transmittance. Suspended particulate matter was collected by a High Volume Sampler, which draws outside air through an 8"x10" filter paper. These samples were collected for twenty-four hour periods. Details concerning these measurements are as follows:

Pollutants	Primary Sources	Method
Oxidant	Photochemical smog	Phenolphthalin
Nitrogen Dioxide (NO_2)	Combustion processes and motor vehicles	Saltzman
Nitric Oxide (NO)	Combustion processes and motor vehicles	Saltzman with prior oxidation of NO to NO_2 by potassium permanganate
Carbon Monoxide (CO)	Motor vehicles and combustion processes	Adaptation of National Bureau of Standards detector tube technique
Sulfur Dioxide (SO_2)	Combustion of sulfur containing fuels and industrial processes	Iodine

Pollutants	Primary Sources	Method
Hydrogen Sulfide (H_2S)	Industrial processes	AISI automatic sampler with lead acetate impregnated tape
Particulate Matter	Combustion processes, motor vehicles, industrial processes and other dusts	(1) AISI automatic sampler, (2) High volume sampler, (3) Visibility determinations

Illustration No. 1 shows some of the sampling equipment used. Illustration No. 2 shows a high volume sampler with a clean new filter paper and one that has been attached to the sampler for a twenty-four hour period.

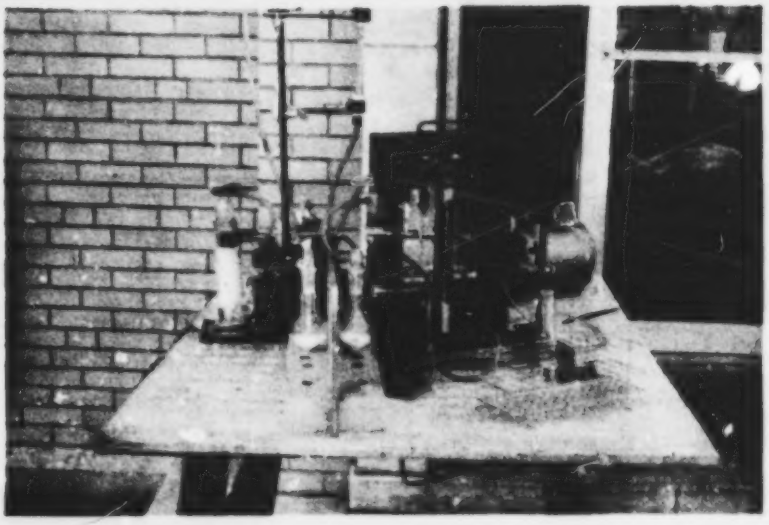

Illustration No. 1

Some of the sampling equipment used during study.

Illustration No. 2

High Volume Sampler with new filter paper and one exposed for 24-hour sampling period

Chemistry

Air pollution chemistry is still relatively new and the Lynchburg Water Department chemistry laboratory had to adapt some new and difficult analyses for use in this study. Such methods were particularly necessary for the analysis of nitrogen dioxide, nitric oxide, and oxidant. All of the methods used have been previously tested and are considered reliable.

Data

Table 1 lists the maximum levels of pollution which were found during the study period.

The maximum levels of oxidants, nitrogen dioxide, sulfur dioxide, smoke and particulate matter are indicative of an air pollution problem. The maximum level of 0.08 ppm oxidant is about one-third of the level of 0.25 ppm which may cause eye irritation in some people. The maximum level of 0.39 ppm sulfur dioxide is comparable to levels found in many large population centers or highly industrialized areas. This maximum sulfur dioxide level also exceeds the 0.3 ppm level which is known to cause damage to plants by an eight-hour exposure. The high levels found for soiling capacity and particulate matter and the instances of reduced visibility indicate a general smoke problem.

Figures 1 and 2 show the parallel variations for maximum levels of certain gaseous and particulate pollutants together with the average daily wind speed. In general, pollution levels for both gaseous and particulate pollutants increased with a decrease in the average daily wind speed. A combination of meteorological conditions, such as low wind speed and a temperature inversion, caused greater air pollution accumulations the morning of February 15. During this period a definite haze layer

existed in the Lynchburg area, with clear weather and unlimited visibility on the plateau and hazy conditions and very limited visibility within the confines of the James River Valley. The Weather Bureau Station referred to this as a ground level inversion in the river valley, a condition that occurs rather frequently in this area. During this period the pollutant levels increased significantly; the nitrogen dioxide and nitric oxide levels more than doubled; the sulfur dioxide, carbon monoxide, particulate and soiling capacity levels more than tripled. All of these increases occurred in a matter of two to three hours and following a change in meteorological conditions, the levels all returned to near normal. This is an indication that, during periods of low wind speed or temperature inversion that persist for several hours or several days, the gaseous and particulate pollutants may accumulate until much higher levels are reached.

Although the study included sampling for hydrogen sulfide (H_2S), no detectable concentrations were obtained. It was expected that this particular pollutant would be detectable because of the past incident of paint blackening, something that is normally associated with hydrogen sulfide. It is understood that the only known source of significant hydrogen sulfide production in Lynchburg was not operated during the study period.

Table 1

Maximum Pollution Levels

Lynchburg, Virginia February 9-15, 1961

Date	Oxidant ppm	NO_2 ppm	NO ppm	Soiling Capacity cohs/ 1000 l. f.	CO ppm	SO_2 ppm	Particulate (1) Matter ug/ cu M	Lowest visibility in miles when relative humidity less than 70 per cent
Thursday, Feb. 9	0.04	0.03	0.02	2.3	0.40	0.08	117	2
Friday, Feb. 10	0.07	0.04	0.02	1.5	0.40	0.08	144	2
Saturday, Feb. 11	0.07	0.04	0.04	2.7	0.33	0.11	160	1.5
Sunday, Feb. 12	0.08	0.01	0.02	1.3	0.00	0.11	87	2
Monday, Feb. 13	0.04	0.01	0.01	1.8	0.33	0.10	94	-
Tuesday, Feb. 14	0.06	0.04	0.02	2.7	0.40	0.15	183	1.5
Wednesday, Feb. 15	0.06	0.07	0.05	5.1	1.67	0.39	269	0.25

(1) Particulate concentrations are reported for the day on which the sampling was completed. (Sampling period from 4 p.m. to 4 p.m.)

Figure 1. DAILY MAXIMUM LEVELS FOR PARTICULATE AND SULFUR DIOXIDE WITH AVERAGE DAILY WIND SPEED

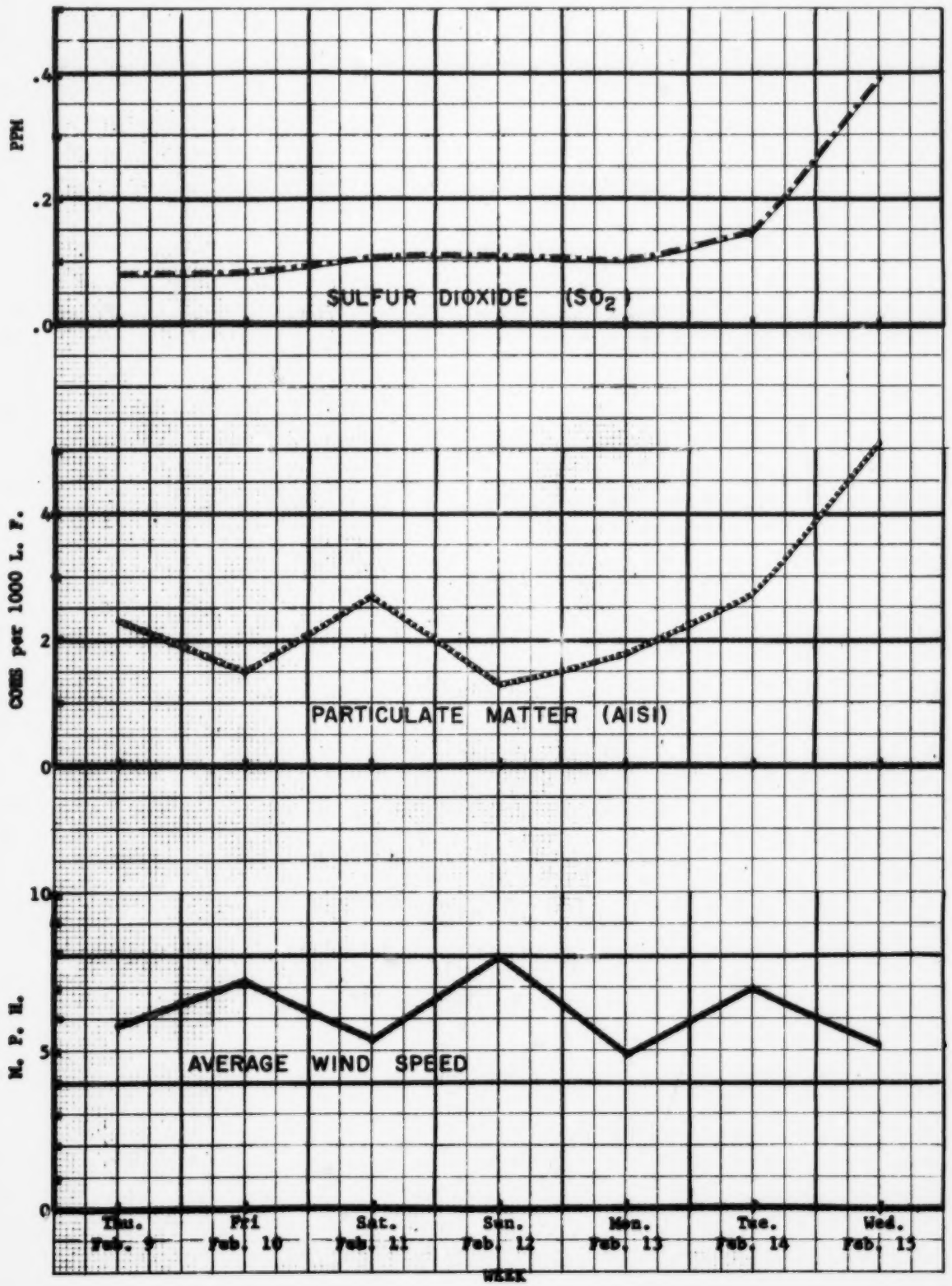

Figure 2. DAILY MAXIMUM LEVELS FOR NITROGEN DIOXIDE AND OXIDANT WITH AVERAGE DAILY WIND SPEED

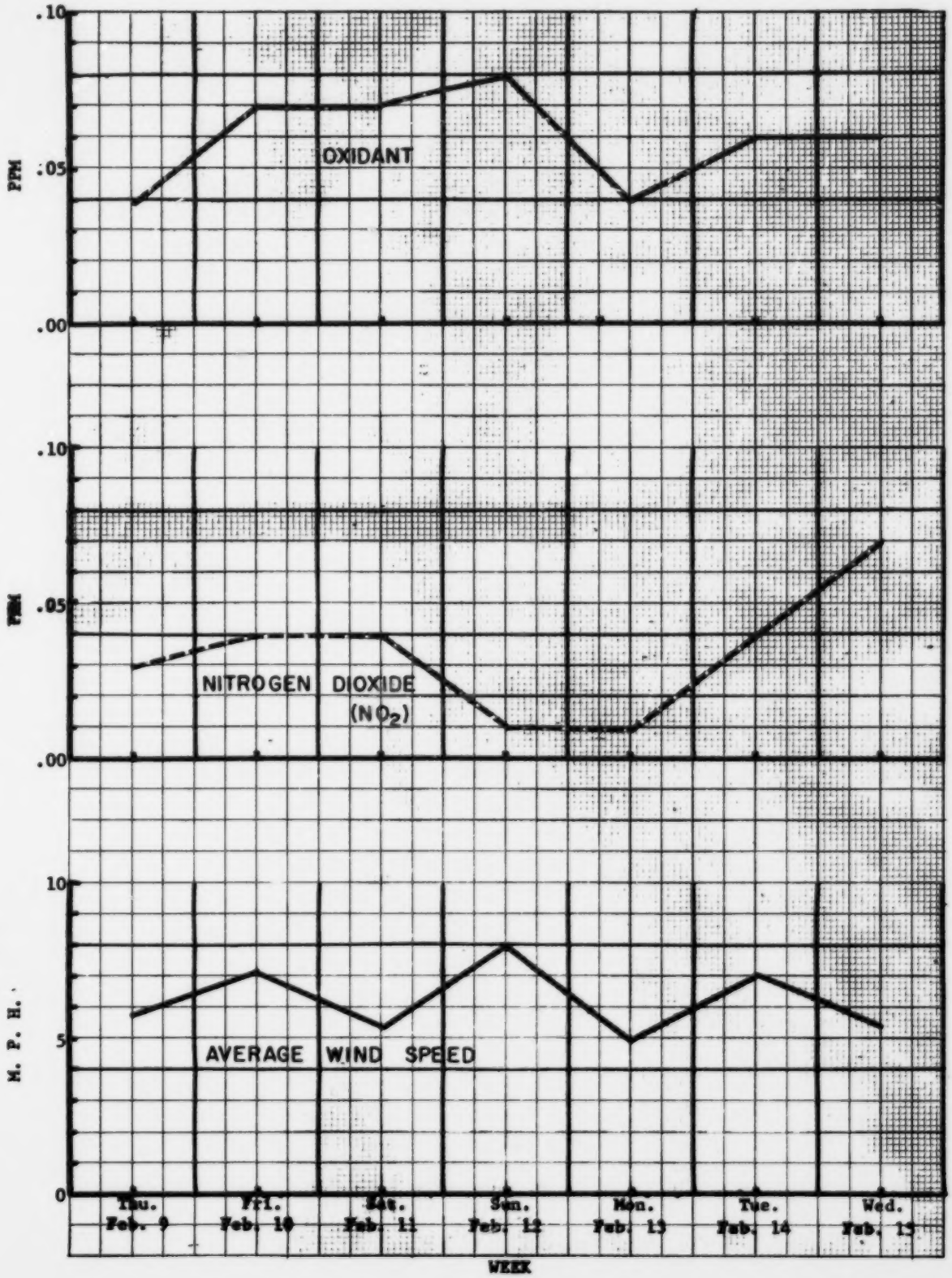

Table 2 gives the complete AISI soiling capacity sampling results for the respective three-hour sampling periods during the seven days of the study. The levels reach a general peak for both the 6-9 a. m. and 9-12 a. m. periods. This coincides with the strong early morning temperature inversions, the heavy motor vehicle traffic and the "heating up" period for industrial, commercial and residential facilities. Levels fall to a minimum for 12-3 p. m. when atmospheric dispersion is greatest and then rise to a secondary peak in the evening due to motor vehicle traffic and the onset of temperature inversion.

Table 2

Soiling Capacity Results

Lynchburg, Virginia February 9-15, 1961
cohs/1000 linear feet

Date	12-3 a.m.	3-6 a.m.	6-9 a.m.	9-12 a.m.	12-3 p.m.	3-6 p.m.	6-9 p.m.	9-12 p.m.	Average
Thursday, Feb. 9	0.5	1.0	2.3	1.1	1.0	1.5	1.1	1.5	1.3
Friday, Feb. 10	0.7	0.9	1.5	0.9	1.0	0.7	1.1	1.1	1.0
Saturday, Feb. 11	1.9	2.6	2.7	3.1	1.0	1.0	1.6	2.0	2.0
Sunday, Feb. 12	1.3	1.3	1.1	1.3	1.3	1.3	1.3	0.9	1.2
Monday, Feb. 13	1.0	0.7	0.9	0.9	0.5	0.9	1.8	1.8	1.1
Tuesday, Feb. 14	2.0	2.2	2.7	3.1	0.7	1.1	1.8	2.5	2.0
Wednesday, Feb. 15	1.8	2.7	3.1	5.1	0.5	0.9	1.8	3.3	2.4
Average	1.3	1.6	2.1	2.2	0.9	1.1	1.5	1.9	

Table 3 gives selected meteorological data together with computations for atmospheric stability at the time of the 7:00 a. m. atmospheric temperature sounding at Greensboro, North Carolina. Stability was computed by subtracting 5.5° F. (abiabatic lapse rate) from the respective ground level temperatures, at approximately 1000 feet above sea level, and then by taking the difference between this calculated temperature and the measured temperature at 2000 feet above sea level. A plus difference (shown by "yes" in Table 3) indicates a higher measured temperature than the computed figure and is indicative of stable conditions (unfavorable to air dispersion), whereas a minus difference indicates unstable conditions favorable to air dispersion.

For the 7:00 a. m. atmosphere temperature soundings at Greensboro, North Carolina, inversions occurred each of the seven days of the study; however, on February 12 Lynchburg was in a different air mass than Greensboro at the time of the sounding so that the data was not applicable. The stability computations shown in Table 3 indicate that stable atmospheric conditions, which are unfavorable to air dispersion, existed on six of the seven days of the study.

Table 4 shows the frequency distribution and the total number of samples for the five gaseous pollutants during the study period. This gives an indication of both the maximum and minimum levels that were obtained.

Table 3

Selected Meteorological Variables for February 9-15, 1961
From U. S. Weather Bureau Data, Preston Glenn Airport, Lynchburg

Date	Max. Temp. ° F	Min. Temp. ° F	Wind			Total Minutes Sunshine Per Day	Atmospheric Stability	Min. Visibility in Miles when Rel. Humid. Less than 70%	Per Cent Rel. Humid. at Time of Min. Visibility
			Ave. Speed MPH	Max. Speed MPH	Direc. of Max. Speed				
Thursday, Feb. 9	41	31	5.8	13	West	135	Yes	2	61
Friday, Feb. 10	46	33	7.2	13	West	552	Yes	2	46
Saturday, Feb. 11	45	30	5.4	12	West	128	Yes	1.5	67
Sunday, Feb. 12	49	30	8.0	21	N. East	446	-	2	64
Monday, Feb. 13	36	29	4.9	11	N. East	7	Yes	-	-
Tuesday, Feb. 14	62	30	7.0	16	S. West	443	Yes	1.5	60
Wednesday, Feb. 15	57	37	5.2	13	N. West	241	Yes	0.25	45

(1) Visibility observations from air sampling station - city sewage treatment plant

Table 4

Total Samples and Distribution
of Gaseous Pollutant Levels
Lynchburg, Virginia
February 9-15, 1961

Pollutant	Total Samples	Parts Per Million (ppm)			
		0-0.020	0.021-0.040	0.041-0.060	0.061-0.080
Oxidant	76	17	41	15	3
Nitric Oxide (NO)	55	50	5	0	0
Nitrogen Dioxide (NO_2)	53	37	12	2	2
Pollutant	Total Samples	Parts Per Million (ppm)			
		0-0.10	0.11-0.20	0.21-0.30	0.31-0.40
Sulfur Dioxide (SO_2)	52	45	6	1	1
Pollutant	Total Samples	Parts Per Million (ppm)			
		0.0-0.5	0.51-1.0	1.1-1.5	1.51-2.0
Carbon Monoxide (CO)	51	45	4	0	2

Interpretations and Comparisons

The effect of combined meteorological conditions upon air pollution was also clearly demonstrated by the rapid and pronounced increase of most pollutant levels during the period of low wind speed and temperature inversion that was experienced the morning of February 15. In fact, the pollutant levels found during this period were the maximums for February 15 as well as the maximums for the entire seven-day period.

Comparisons are particularly appropriate for the following pollutants:

1. Oxidants rose to the level of 0.08 ppm which is about one-third of the 0.25 ppm level at which some people experience eye irritation. In the air pollution standards for ambient air adopted by the California State Department of Public Health, the standard for oxidant is given as "0.15 ppm for one hour by the potassium iodide method", which is equivalent to approximately 0.3 ppm for one hour by the phenolphthalin method used in this study. Therefore, the recognized oxidant standard was not exceeded during the sampling period.

2. The California standard for particulate matter is "adverse" when visibility is reduced to less than three miles when relative humidity is less than 70 per cent. This standard was exceeded on six of the seven days covered by the sampling period. A large portion of the particulate matter appeared to be smoke pollution.

3. The average level for suspended particulate matter is comparable to average levels found in Baltimore, Boston, Detroit and Cincinnati, all large population centers and heavily industrialized areas.

4. The soiling capacity level is considered high, values in excess of 2.0 cohs per 1000 l.f. occurred during five of the seven days. This is another indication that the air contains a significant amount of suspended particulate matter.

5. The level for sulfur dioxide is comparable to levels found in large population centers or highly industrialized areas.

6. The California standard for sulfur dioxide is 1.0 ppm for one hour or 0.3 ppm for eight hours. This standard was not exceeded, but it was clearly indicated that this could happen during periods of low wind speed or temperature inversion.